MULTIPROGRAMMING ON THE COMPATIBLES/600

SALES ANALYSIS

LINEAR PROGRAMMING

SIMULTANEOUS EQUATIONS

SIMULATION

ORDER PROCESSING

INVENTORY CONTROL

TEST STAND MONITOR & CONTROL

GENERAL ELECTRIC

Multiprogramming on the Compatibles/600 reduces turn-around time, increases computations per dollar, and increases equipment utilization through a unique integration of hardware and software. GE-600 multiprogramming eliminates the peripheral computer systems often required for media conversion in a large-scale computer installation. GE-600 multiprogramming permits the simultaneous operation of real-time programs and regular processing.

A better understanding of how GE-600 multiprogramming saves time and money is aided by an explanation of how multiprogramming evolved, and how it works.

A definition of terms is a good starting point . . .

Multiprogramming — multiple object programs, residing in a single system core memory, that are alternately executed by a processor to gain greater throughput through simultaneous input/output and processor operation of multiple programs.

Multiprocessing — two or more processors executing programs residing in a system core memory. In multiprocessing, one of the processors acts as a system control processor, and the other processors on the system are subordinate to it.

Multicomputing — two or more system control processors each operating as an independent computer system but with the capability of directly communicating between their respective memories.

Turn-around time — the total time from job request to job delivery.

Real-time processing — the processing of data in a sufficiently rapid manner so that the results of the processing are available as it is monitored, or to influence the process if it is controlled.

R = Read input
C = Compute
W = Write output

Multiprogramming evolved from sequential and simultaneous processing. A review of these earlier modes will illustrate its time-saving results.

Most of the first computers were sequential — processing went like this:

With sequential systems, only one operation (either read, or write, or compute) was possible at one time.

The next advancement that came along was overlapped read/write/compute. Even with overlapping, the processor was not fully utilized; notice the processor idle periods.
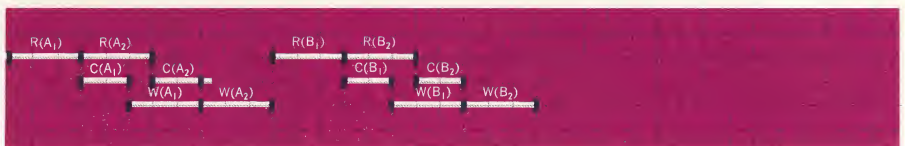
Overlapping required much ingenuity and attention on the part of the object programmer and it was not usually well done.

GE-600 multiprogramming achieves the next step in improving computer performance. That is, processor, memory, and peripherals utilize time with maximum efficiency.

The processor and I/O controller initiate new tasks as soon as they complete previous tasks. This results in increased efficiency of each device, and increases total throughput.

When program A has initiated its input or output operations and can't use the processor any longer, program B can use the processor to do its computing. When program B has initiated its I/O operations, and can't use the processor any longer, program A is again free to use the processor, or program C may be entered.

HOW MULTIPROGRAMMING WORKS IN THE COMPATIBLES/600

SOFTWARE FOR MULTIPROGRAMMING

It's easier than you'd expect. And it's completely automatic. It's all made possible by GECOS — the General Comprehensive Operating Supervisor. GECOS keeps preparation for multiprogramming very simple. A programmer need not be concerned with the fact that he is programming for a multiprogramming environment; on the contrary, he writes his program as if it were to be the only one in the computer.

The high throughput rates achieved by the Compatibles/600 could not have been reached through software alone — or hardware alone. The software and its basic design is deeply integrated with hardware features specifically designed for multiprogramming.

GECOS is organized into five modules. The more frequently used elements of the modules reside permanently in memory, while less frequently used sections are called from drum storage as temporary overlays when needed. Each module is functionally independent, but some of them perform their functions simultaneously. Thus, several programs may be simultaneously in process: one being read in and examined for processing requirements; a second undergoing peripheral and memory allocation; another conducting actual processing; up to eight programs may be having input/output performed; others undergoing termination procedures; and some having their final results produced. At the same time, others can be queued in storage awaiting their turn.

THE FIVE MODULES

GEIN

Input Media Conversion
- ☐ Reads job from on-line card reader, or any other basic input device
- ☐ Intercepts control card information
- ☐ Generates control tables to be used by the next module
- ☐ Records the job onto the magnetic drum

Each job is considered to consist of one or more dependent activities. The activities of a job are segregated in this module, and the activities are then presented in an ordered manner to the Allocation module.

GEALOC

Allocation
- ☐ Examines control tables and determines gross peripheral requirements for that activity
- ☐ Allocates specific peripherals
- ☐ Issues instructions to the operator, if required, from information in the control tables
- ☐ Allocates specified memory
- ☐ Initiates programs as peripherals and memory allocations are completed

Scheduling and allocating of peripherals is done via the scheduling algorithm. Modifications or extensions can be made to the basic algorithm to meet specific needs. Refinement of the algorithm is practical because of the modular construction of GECOS.

Peripherals are allocated to activities in advance of execution thus allowing operators to perform functions (such as mounting tapes) while prior programs are in execution. When the assigned peripherals are ready and sufficient memory is assigned to the activity, the Allocation module initiates the program and assigns the activity for in-process Execution control.

GESERV

Execution
- ☐ Oversees the execution of each activity
- ☐ Provides user communication with GECOS
- ☐ Supervises execution of all input/output
- ☐ Interprets processor fault conditions
- ☐ Controls Master Mode entry from job programs
- ☐ Polices GECOS memory overlay area

This module also contains the system loader. It initiates job and activity termination that can be caused by an end-of-program, or unrecoverable error condition. Control is then turned over to the next module.

GETERM

Termination
- ☐ Produces an accounting record on the systems output file
- ☐ Produces a post mortem dump if the termination was not normal
- ☐ Closes the systems output file
- ☐ Communicates with the operator for the removal of files when needed
- ☐ De-allocates memory and peripherals
- ☐ Deletes tables used by GESERV during program execution

The module now branches to a portion of permanent GECOS storage where core storage is compacted, if necessary. Control is then relinquished to the Allocation module for the re-allocation of released peripheral devices and memory.

GEOUT

Output Media Conversion
- ☐ Transcribes output written on a standard system output file into printer output or punched cards
- ☐ Automatically initiates movement of data to output devices

Dual Mode Processor

Each processor is capable of operating in two modes: the Slave Mode, or the Master Mode. With two distinct modes, only the operating system is allowed to perform certain control functions. Without dual mode operation, multiprogramming would require extreme discipline by the user to insure that he did not assume operating system functions.

In Master Mode, no restrictions are imposed on a program. In Slave Mode, a program is prevented from accessing memory or peripheral devices, or areas belonging to other programs. GECOS operates in the Master Mode, whereas job programs operate in the Slave Mode under control of GECOS.


Base Address Register (BAR)

The BAR controls memory references when the processor operates in Slave Mode. It contains a base address associated with the job program. The address is automatically added to job program addresses, as appropriate, at execution time. This provides positive memory protection. Programs reside in memory in relocatable form.

The BAR can be reset only in the Master Mode. The BAR also permits entire job programs to be relocated in memory. It permits efficient consolidation of memory areas that have been relinquished upon program terminations. Thus, it is possible to interrupt a job program, place it in temporary storage, and later return it to any available block of memory without the need for software relocation.


Input/Output Memory Protection

Each input/output channel on an Input/Output Controller has hardware provisions for checking reads and writes to and from memory to prevent trespassing in preassigned data transfer area limits. Input/output activities requested by a job program do not disturb any other unrelated job programs.
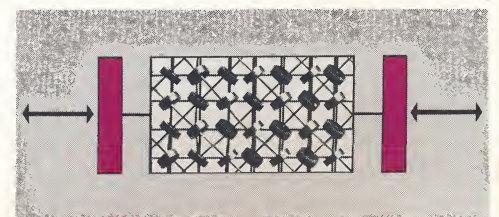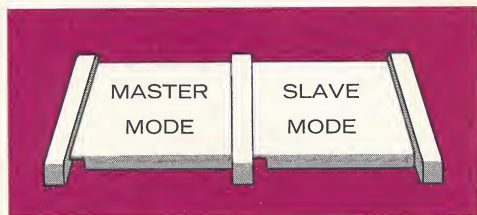
Memory-Oriented Design

Memory (rather than processor) orientation gives the system greater capability for multi-programming and multiprocessing. In the Compatibles/600 series, memory serves as a coordinating passive system component which provides both information storage and system communication control. The memory and its controller effectively initiate input/output operations, and notify the processor upon operation termination. Peripheral data transfers bypass the processor, keeping it free for productive work.
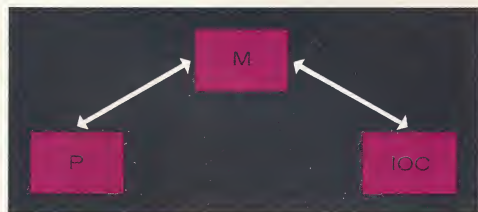
Complete Interrupt System

In a multiprogramming system, it is necessary to free both the equipment and the program from specific timing requirements and from the burden of checking other components of the system, either for task completion or for requests for service. Therefore, in the Compatibles/600, devices that have completed tasks or that require service generate their own interrupts to instruction processing. These interrupts can be generated by processors as well as by input/output devices. Specific equipment features in the system implement this interrupt-oriented philosophy.
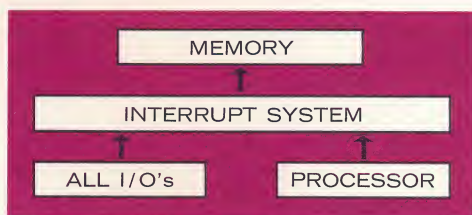

Interval Timer

The Interval Timer is a 24-bit register that is automatically decremented every 15.625 microseconds. When the count reaches zero, an interrupt is generated. The timer has three basic functions:

1. To provide GECOS with a timer for system control. For example, to time job programs for automatic job termination.
2. To prevent a job program from monopolizing a processor.
3. To provide accounting information by monitoring elapsed time of processor and I/O activities.

The timer can be loaded or set only in the Master Mode.
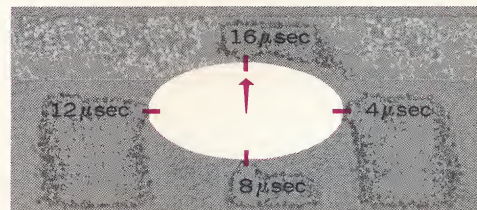
Fault Interrupts

Multiprogramming in a real-time application requires continuous on-line operation. The processor must respond immediately to high level interrupts, called "faults". Any operation that might otherwise cause the system to "hang up" causes an automatic fault into the Master Mode control program, so that immediate remedial action can be taken.
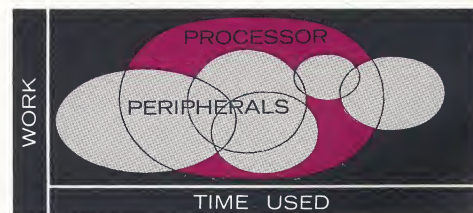
Real-Time Interface

The real-time interface permits real-time devices to communicate directly with memory. The interface, together with memory, permits independent data movement and program initiation under complete control of the external device. Thus, the external device can operate in either the conventional processor-controlled mode, or in a self-controlled mode.
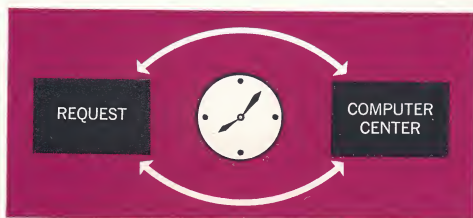
Maximizes Equipment Use

With the Compatibles/600, you get full value for your equipment rental dollar because multiprogramming with GECOS keeps processor and peripherals operating a greater share of the time. GECOS "force feeds" the processor to prevent any idle periods when the processor is waiting for the peripherals. Automatic job scheduling and peripheral allocation determine the best way to utilize available equipment for each job.

Increases Throughput Without Duplicating Systems

Presume a business data processor is input/output bound, and that it is effectively using the processor only about 50 percent of the time. A complete duplication of systems will double the throughput, but the processors are still idle 50 percent of the time.

A more economic approach is to increase processor use through multiprogramming. With the addition of more peripherals, multiprogramming can use the processor to its full effectiveness, and increase the throughput at a fraction of the cost of system duplication. Multiprogramming **is** recommended for I/O limited programs.

When an installation is processor limited, multiprogramming significantly increases the throughput without duplicating the entire system. Adding only a second processor, and possibly some memory, multiprogramming increases the throughput to achieve very favorable cost/performance ratios.

Optimizes Systems With Mixed Problems

Scientific and engineering processing loads generally require more processor/memory capability than I/O capability. Conversely, business data processing requires heavy I/O capabilities and less processor/memory.

When a conventional installation does both types of processing, a poor efficiency factor has to be tolerated. That is, on business data processing problems the processor idles while the peripherals do their work, and on scientific problems, the peripherals are idle while the processor works.

Multiprogramming achieves optimum use of the system by processing **both** types of problems simultaneously. GECOS gives the scientific problem most of the processor time, allowing the business data processing problem sufficient time to do calculations and keep the required peripherals busy.

Reduces Turn-Around Time

The time between "job request" and "job delivery" is shorter with the GE-600 multiprogramming approach than it is with the peripheral processor method. The bottleneck of input and output conversion is eliminated. The Compatibles/600 perform these tasks on-line, simultaneously with other production processing.
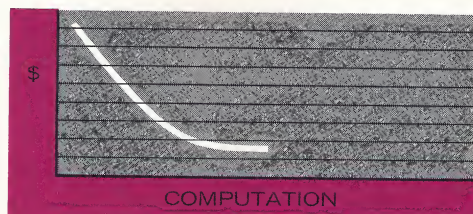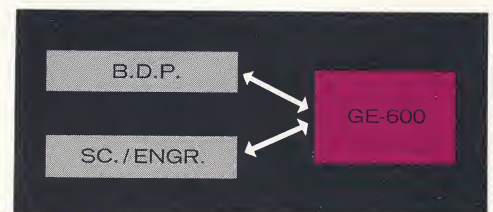

Reduces Computation Costs

Multiprogramming reduces the cost per computation by increasing the efficiency of the processor and the entire system. Delays attributable to setup are minimized through the use of the look-ahead feature of GECOS that anticipates the time-consuming activities required of the operator.

Eliminates Peripheral Processor and Off-Line Controllers

Multiprogramming at a centralized data processing center eliminates many small systems scattered at various company locations. Management can have more processing power than it had previously, and remote locations can do a more efficient job by using the facilities of a larger computer. Many companies have learned that a centralized system is not only more efficient, but less expensive than the combined rental of their many small systems.

The commercial portion of the Compatibles/600 family includes the GE-625 with a 2-microsecond memory, and the GE-635 with a 1-microsecond memory.

The military portion of the family includes the A-605 (micro-miniaturized, airborne), the M-605 (ground-based, general-purpose), and the M-625 (militarized version of the GE-625). The family concept provides program compatibility among mission computers. Programs for the military computers can be compiled, assembled, and checked out on the commercial systems.

For more information about the Compatibles/600 and multiprogramming, informative seminars may be arranged at your convenience. Contact the General Electric Computer Department District Office nearest you.

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